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COMPARISON OF FOUR SINGLE-STEM METHODS FOR CONTROLLING TREMBLING ASPEN

by
Sylvi D. Holmsen, R.P.F.

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Abstract

In 1989, four single-stem vegetation-control methods were used on trembling aspen overstory on two study sites, at Prince George and Kelowna in British Columbia. The study compared cost and productivity of four treatments: hack-and-squirt, GEL CAP, EZJECT, and girdling. The study also established permanent sample plots and collected baseline data for monitoring the efficacy of treatments and the effect of the treatments on understory plant communities. The project was funded by the Federal Direct Delivery component of the Canada/British Columbia Forest Resource Development Agreement (FRDA).

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Summary

Broadcast application of herbicides may not be suitable where waterways or private land can be affected by such treatment. In October 1988, the Forest Engineering Research Institute of Canada (FERIC) and Forestry Canada (Pacific Forestry Centre) initiated a study to compare the productivity and cost of four single-stem vegetation-control methods used on trembling aspen. The four treatments were hack-and-squirt, GEL CAP™,[1] EZJECT™,[2] and girdling. The study also established permanent sample plots and collected baseline data for monitoring the efficacy of the treatments and the effect of the treatments on the understory plant communities in two locations: Prince George and Kelowna. This project was funded by the Federal Direct Delivery component of the Canada/British Columbia Forest Resource Development Agreement (FRDA).

At the time of treatment, vegetation on the sites consisted of an aspen overstory, varying in density from 3980 to 12 030 trees/ha, as well as an understory composed of mixed trees, shrubs, and forbs including alder, conifers, black twinberry, gooseberry, thimbleberry, Utah honeysuckle, wild sarsaparilla, rose, and pinegrass. All of the conifer seedlings examined had good vigour but were not free-growing, and all experienced competition from the aspen and the understory vegetation. Aspen stem diameters on the two sites ranged from one centimetre to 18.7 cm, with averages of 3.9 cm in Prince George, and 4.4 cm in Kelowna.

Productivity for the various treatments ranged from 0.10 to 0.43 ha/manday. At the Prince George site, the GEL CAP method was the most productive, with an average of 0.31 ha/manday; at the Kelowna site, the EZJECT and girdling methods had higher productivities, 0.27 and 0.26 ha/manday respectively, than the GEL CAP method. Hack-and-squirt treatment had the lowest productivity on the Kelowna site at 0.10 ha/manday, but the second highest at Prince George at 0.30 ha/manday. Costs for the four methods, based on the labour and chemical components only, ranged from $370/ha to $2313/ha. The most expensive method on all sites was the GEL CAP treatment, mainly because of the high cost of the capsules, at approximately $0.18 each. Girdling, on the other hand, was the least expensive method, although the hack-and-squirt system had similar costs on the Prince George site. Stems less than 2 cm were difficult to treat with any of the methods except the hack-and-squirt which became more of a cut-stump treatment. Statistical analysis of the results indicated that productivity was affected by the number of aspen trees per hectare, the treatment method, and the operator.

FERIC assessed and summarized the quality of treatment at the two locations immediately following completion of the work. Overall, the quality of the treatments was good; however, the Prince George hack-and-squirt treatments had 84% and 90% acceptably treated trees, compared to greater than 94% for the remaining treatment units. The study did not include follow-up efficacy assessment. Future evaluations of the treated trees will indicate the efficacy of each treatment in terms of mortality; this will determine the long-term cost effectiveness associated with each treatment.

[1] GEL CAP™ is a trademark of Pace Chemicals Ltd.

[2] EZJECT™ is a trademark of Monsanto Company U.S.A. Monsanto Canada Inc. is a registered user.

INTRODUCTION

Because western Canadian mills have recently realized the economic value of aspen, it is becoming a commercial species. However, on many sites it competes with a more valuable conifer crop and must be controlled. Ground or aerial spraying of herbicides is often the prescribed treatment for reducing competition to conifers both in plantations and on naturally regenerated sites. However, these methods of application may not be suitable in some situations; for example, where waterways or private land preclude broadcast treatment.

Single-stem treatments may be more acceptable and need to be evaluated for cost and effectiveness. Studies involving the cutting of individual stems, either by chain saws or clearing saws, have found that several treatments are required to release the conifers because resprouting of the aspen from stumps and suckering from roots are very common. A method that incorporates herbicide and delivers the chemical directly to the target may offer an effective alternative.

In October 1988, the Forest Engineering Research Institute of Canada (FERIC) and Forestry Canada initiated a study, funded under the Federal Direct Delivery component of the Canada/British Columbia Forest Resource Development Agreement (FRDA), to evaluate four single-stem vegetation-control treatments used on trembling aspen sites near Prince George and Kelowna, British Columbia. The four treatments were:

- Hack-and-Squirt
- GEL CAP™ [3]
- EZJECT™ [4]
- Girdling

Major objectives of this study were to:

- Compare the productivity and cost of the four single-stem vegetation-control treatments used on trembling aspen.
- Establish plots and collect baseline data for monitoring the efficacy of these treatments, and monitor the effect of the treatments on the understory plant communities.

In July 1989, FERIC conducted pretreatment assessments of the deciduous overstory, conifers, and understory vegetation, followed by productivity assessments of the four single-stem control methods in August 1989. Finally, the plots were re-evaluated for completeness and quality of treatment. This report presents the results.

DESCRIPTION OF SITES

FERIC chose two locations for this project, one near Prince George, and the second near Kelowna. The sites at both locations were on even slopes with relatively easy terrain dominated by trembling aspen. However, one of the Prince George blocks included deadfalls and old slash that impeded operator movement. For the purpose of this study, two blocks, with sixteen permanent plots each, were established at each site. Vegetation at both sites consisted of thimbleberry, gooseberry, and twinberry with some willow, alder, Douglas maple, and highbush cranberry.

Prince George

The Prince George site is located near Lamb Lake (approximately 150 km northwest of Prince George) and is classified as SBSe2/01[5] (after De Long et al 1987). The cutblock was logged in 1974/75, burned in 1976, and classified as naturally regenerated with lodgepole pine and spruce in 1985. Since 1985, aspen had become well established on portions of the cutblock. This area, and several nearby cutblocks, were scheduled for aspen control treatment in 1989. As well, the variety of vegetation-management trials in the vicinity of the block make the location useful for future demonstrations of vegetation-management methods. Vegetation at the time of treatment was composed of shrubby and herbaceous species in the well-developed shrub and forb layers, and a dominant aspen overstory (Figure 1).

Kelowna

The Kelowna study sites are near Bighorn Creek and Lambly Lake in the Bear Creek drainage (approximately 40 km west of Kelowna) and are easily accessible by road. Both blocks are in the MSdm2 subzone; however, the Bighorn Creek block is classified MSdm2/01[6] while the Lambly Lake block is classified as MSdm2/03.2[7] (after Lloyd et al 1989). The site at Bighorn Creek was logged in 1975 and planted in 1979. Seedling survival is marginal although the site has been classified as stocked. Logging started at the Lambly Lake site in 1976, with portions logged up to 1982. Aspen was well

Figure 1. Vegetation typical of the Prince George site.

[3] GEL CAP™ is a trademark of Pace Chemicals Ltd.
[4] EZJECT™ is a trademark of Monsanto Company U.S.A. Monsanto Canada Inc. is a registered user.

[5] SBSe2/01 is a mesic association of the Mossvale Moist Cool Sub-Boreal Spruce climatic subzone.
[6] MSdm2/01 is a mesic association of the Thompson Plateau Dry Mild Montane Spruce subzone.
[7] MSdm2/03.2 is a submesic association of the Thompson Plateau Dry Mild Montane Spruce subzone.

established on large portions of the two sites. The Bighorn Creek location had poorly developed shrub and forb layers while the Lambly Lake block had a more open aspen canopy with a well-developed understory, particularly in the forb layer (Figure 2).

EXPERIMENTAL DESIGN AND BLOCK LAYOUT

Two 40-m x 40-m treatment blocks were established at each site for a total of four study blocks. Each treatment block was subdivided into sixteen plots (10-m x 10-m) in rows of four, and the four treatments were randomly but evenly assigned to the rows. As well, the two operators were randomly assigned to the rows. The layout and design are presented in Appendix I.

PRETREATMENT EVALUATIONS

FERIC carried out pretreatment evaluations in July 1989. Deciduous trees with stems 1 cm and larger in diameter, and all of the conifers in each plot, were tallied by 5-cm diameter class and species (Table 1). The assessments included the selection of a subsample of twenty-five target aspen per plot for detailed data collection. These trees were numbered, and their diameters and vigour were recorded. This information will be used for subsequent treatment productivity and efficacy analyses. Aspen vigour was evaluated on a scale of 1 to 9 based on previous work done by B.C. Hydro[8] and John Bartlett.[9] FERIC modified these codes slightly for use in these assessments (Table 2) and used only the codes from 1 to 3 to describe the pretreatment vigour of each tree. Aspen densities averaged 6300 stems/ha on the Prince George site, and 8420 stems/ha

Figure 2. Typical vegetation at Lambly Lake site, Kelowna.

Table 1. Pretreatment Assessment of Aspen Cover

Treatment method	Block	Prince George Stems/ha[a] Aspen	Other	Total	Aspen Average diameter (cm)	Average vigour	Kelowna Stems/ha[a] Aspen	Other	Total	Aspen Average diameter (cm)	Average vigour
EZJECT	1	4 330	2 750	7 080	3.9	1.2	5 700	1 780	7 480	5.4	1.5
	2	7 830	6 750	14 580	4.0	1.2	8 950	1 950	10 900	3.5	1.4
Girdling	1	5 000	1 250	6 250	3.8	1.3	5 800	2 900	8 700	5.1	1.6
	2	7 800	7 700	15 500	3.7	1.4	9 700	1 550	11 250	3.7	1.4
Hack-and-squirt	1	3 980	680	4 660	3.8	1.2	7 550	1 930	9 480	4.7	1.5
	2	7 530	8 250	15 780	3.8	1.3	11 250	1 880	13 130	3.7	1.3
GEL CAP	1	5 830	1 180	7 010	4.5	1.1	6 400	2 950	9 350	5.0	1.6
	2	8 130	8 680	16 810	3.5	1.3	12 030	1 030	13 060	3.6	1.3
Weighted averages		6 300	4 650	10 950	3.9	1.2	8 420	2 000	10 420	4.4	1.5

[a] Rounded to the nearest 10.

[8] H.M. Ellis, 1987, "Ins · ctions for participants in the herbicide capsule evaluation program"; B.C. Hydro, Research and Development, unpublished material.

[9] J.C. Bartlett, forestry consultant; pers. comm., Aug. 1988.

on the Kelowna site. However, at Prince George, alder accounted for an additional 4650 stems/ha, and at Kelowna a willow/maple component was approximately 2000 stems/ha. The average diameters at breast height (dbh) at Prince George and Kelowna were 3.9 and 4.4 cm respectively, with an overall range of 1 cm to 18.7 cm. There was some variation between the two blocks on each site, and this was analyzed using analysis of variance (ANOVA) (Table 3). At both locations, Block 1 had a significantly lower density of aspen than Block 2 and subsequently higher average diameters. However, further testing indicated that there were no significant differences in aspen density for the treatments or in average diameters between the two sites. There were, however, significant differences in average diameters for the various treatments. A Student-Newman-Keul's Multiple Range Test was applied to the diameter data (Table 4) to identify where the differences occurred.

On the whole, the aspen trees at both locations were very vigorous. The aspen at Prince George exhibited slightly, although not significantly, better vigour than those at Kelowna (Table 1). At Kelowna, the aspen in Block 2 had significantly better vigour than in Block 1, probably due to the more open nature of the aspen growth in Block 2.

At the time of the aspen-cover evaluations, a subsample of one plot in each treatment was randomly selected and examined to describe the vegetative composition and crop trees. Species, size, vigour, and distribution of the understory vegetation were recorded, based on study methods described by Whitehead.[10] These pretreatment data are summarized in Table 5 and can be used for subsequent evaluations of understory species shifts. In these sample plots, FERIC also mapped and tagged live conifers within a 50-m² circular plot for monitoring crop-tree response. Measurements of these seedlings included species, height, leader growth, free-growing status, and vigour (Table 6). As well, FERIC recorded the number and species of all conifer seedlings in each plot to determine the stocking of crop trees on the site.

Table 2. Vigour Codes for Aspen

Vigour codes	Description
1	Very vigorous, dominant
2	Vigorous, or very vigorous but intermediate
3	Vigorous but damaged, i.e. scarred
4-5	Moderate vigour, some stress symptoms
6-7	Poor vigour, severely stressed
8	Death imminent
9	Dead and defoliated

Table 4. Student-Newman-Keul's Multiple Range Test of Aspen Diameter Within Each Treatment [a]

	CEL CAP	EZJECT	Girdling	Hack-and-squirt
Mean (cm)	4.33	4.13	4.03	3.58

[a] Means underlined by the same line are not significantly different ($p < 0.05$). Note: The treatment means are rounded least squares means of the diameter data from the subsamples for each plot. (The effects of unequal numbers in the various classes have been removed.)

Table 3. Analysis of Variance for Aspen Pretreatment Data

Source	Degrees of freedom			Probability >F		
	DBH	No. aspen	Vigour	DBH	No. aspen	Vigour
Site	1	1	1	0.0001 [c]	0.0086 [c]	0.0001 [c]
Site x block	2	2	2	0.0001 [a]	0.0001 [a]	0.0001 [a]
Operator	1	1	1	0.3519 [c]	0.5162 [c]	0.9245 [c]
Treatment	3	3	3	0.0147 [b]	0.6112 [c]	0.1084 [c]
Operator x treatment	3	3	3	0.2580 [c]	0.5845 [c]	0.6306 [c]
Site x operator	1	1	1	0.4904 [c]	0.3335 [c]	0.3810 [c]
Site x treatment	3	3	3	0.0243 [b]	0.6754 [c]	0.2669 [c]
Site x operator x treatment	3	3	3	0.2601 [c]	0.6171 [c]	0.2580 [c]
Error	1 577	46	1 577			
Corrected total	1 594	63	1 594			

[a] Highly significant, probability (of being due to chance) ≤1%.
[b] Significant, probability (of being due to chance) ≤5%.
[c] Not significant, probability (of being due to chance) >5%.

[10] R.J. Whitehead, 1985, "Description of plant community response to vegetation management treatments"; Canadian Forestry Service, unpublished draft report.

Table 5. Pretreatment Assessment of Most Common Vegetation[a]

Layer	Location	Description[b,c]
Tree layer	Prince George	Block 1—25-70% cover of evenly distributed trembling aspen, 6.0-7.0 m high.
		Block 2—20-65% cover of scattered to evenly distributed trembling aspen, 8.0-9.0 m high.
	Kelowna	Block 1—60-100% cover of evenly distributed trembling aspen and scattered clumps of willow, 8.0-10.0 m high.
		Block 2—40-65% cover of evenly distributed trembling aspen, 7.5-9.0 m high.
Tall shrub layer	Prince George	Block 1—8-15% cover of scattered sitka alder, aspen, 3.0-5.5 m high.
		Block 2—15-60% cover of scattered sitka alder, aspen, 2.5-6.0 m high.
	Kelowna	Block 1—5-15% cover of scattered clumps of Douglas maple, green alder, willow, 5.0-6.0 m high.
		Block 2—5-15% cover of scattered clumps of maple, saskatoon, red-osier dogwood, willow, 2.0-6.0 m high.
Low shrub layer	Prince George	Block 1—5-10% cover of unevenly distributed clumps of black twinberry, conifers, black gooseberry, thimbleberry, highbush cranberry, 0.8 m high.
		Block 2—30-80% cover of scattered clumps of twinberry, conifers, gooseberry, thimbleberry, cranberry, 0.6-1.1 m high.
	Kelowna	Block 1—15-60% cover of unevenly distributed clumps of Douglas maple, saskatoon, black twinberry, Utah honeysuckle, falsebox, sticky currant, rose, thimbleberry, soopolallie, birch-leaved spirea, 0.3-1.1 m high.
		Block 2—9-50% cover of unevenly distributed clumps of saskatoon, red-osier dogwood, honeysuckle, tall Oregon grape, falsebox, rose, thimbleberry, spirea, conifers, 0.6-0.8 m high.
Forb layer	Prince George	Block 1—30-60% cover of evenly distributed yarrow, wild sarsaparilla, bunchberry, fireweed, twinflower, palmate coltsfoot, birch-leaved spirea, and minor occurrences of queen's cup, wild strawberry, pink wintergreen, 0.3-0.6 m high.
		Block 2—15-30% cover of evenly distributed sarsaparilla, queen's cup, bunchberry, Hooker's fairybells, fireweed, twinflower, coltsfoot, false Solomon's-seal, spirea, and minor occurrences of wild strawberry, wintergreen, sweet-scented bedstraw, 0.3-0.4 m high.
	Kelowna	Block 1—20-85% cover of unevenly distributed clumps of wild sarsaparilla, pinegrass, fireweed, birch-leaved spirea, and minor occurrences of sweet-scented bedstraw, tiger lily, mountain sweet-cicely, false Solomon's-seal, western meadowrue, 0.2-0.3 m high.
		Block 2—15-80% cover of evenly distributed patches and individuals similar to Prince George Block 2, including baneberry, heart-leaved arnica, kinnikinnick, pinegrass, and minor occurrences of sarsaparilla, prince's pine, rattlesnake-plantain, 0.3-0.4 m high.

[a] Additional minor species are listed in Appendix II for each location.
[b] D. Meidinger, 1987; "Recommended vernacular names for common plants of British Columbia"; B.C. Ministry of Forests and Lands, draft report.
[c] Latin names for plants are listed in Appendix II.

Table 6. Codes for Assessing Seedling Vigour and Free-Growing Status

Free-growing code	Free-growing status	Vigour code	Vigour
1	Competition within 1 m of seedling	1	Healthy, vigorous seedling
2	Competition within 1 m and two times seedling height	2	
3	Seedling free growing	3	Stressed seedling
		4	
		5	Dead seedling

The crop trees in the Prince George stand were lodgepole pine and white spruce with a minor component of subalpine fir (Tables 7 and 8). The average density was 2375 seedlings/ha for Blocks 1 and 2 combined. However, the density varied significantly between the two blocks as evidenced by the ranges for the treatments. The crop-tree data for Kelowna examines only Block 2 because Block 1 did not have crop trees in any of the sample plots. The few trees that were present in the unsampled plots in Block 1 exhibited severe stress and damage due to rabbit browsing and were unsuitable for monitoring. The main component in Block 2 was lodgepole pine (50%) with Douglas-fir and hybrid spruce in equal proportions and a minor component of subalpine fir. The average crop-tree density at this site was 860 seedlings/ha.

The conifer seedlings at the Kelowna site had a slightly poorer vigour and free-growing status than those at the Prince George site; however, on the whole, the seedlings at both sites exhibited good vigour. At the Kelowna site, the greater cover of forbs and low shrubs competing with the seedlings may have reduced their vigour. None of the seedlings at either site were considered free growing.

DESCRIPTION OF TREATMENT METHODS

Standard safety gear for the operators consisted of hard hats and sturdy work boots. The operators also used gloves when working with the three chemical methods, plus goggles and coveralls when the hack-and-squirt method was employed.

FERIC selected the four single-stem treatment methods for the study based on the currently available tech-

Table 7. Summary of Pretreatment Data for Potential Crop Trees at Prince George

Treatment method	Block	Crop trees [a] by species			Total/ ha (no.)	Average diameter (cm)	Average height (cm)	Average vigour code	Average free-growing code
		Pl [b] (%)	Sw [c] (%)	Bl [d] (%)					
GEL CAP	1	58.5	40.8	0.7	3 675	1.1	94.5	1.1	1.0
	2	48.1	48.1	3.8	1 300	2.2	294.5	1.0	1.0
Girdling	1	46.3	53.0	0.7	3 350	1.3	96.6	1.3	1.6
	2	49.0	51.0	0.0	1 275	2.2	174.0	1.0	1.0
Hack-and-squirt	1	44.6	55.4	0.0	3 925	0.8	87.3	1.1	1.1
	2	33.3	60.0	6.7	750	2.0	179.9	1.0	1.9
EZJECT	1	43.3	56.7	0.0	3 525	2.2	190.0	1.0	1.3
	2	56.3	33.3	10.4	1 200	1.2	120.3	1.3	1.0
Weighted averages		48.2	50.4	1.4	2 375	1.6	144.8	1.1	1.3

[a] Latin names for crop trees are listed in Appendix II.
[b] Lodgepole pine.
[c] White spruce.
[d] Subalpine fir.

Table 8. Summary of Pretreatment Data for Potential Crop Trees at Kelowna [a]

Treatment method	Block	Crop trees by species				Total/ ha (no.)	Average diameter (cm)	Average height (cm)	Average vigour code	Average free-growing code
		Pl [b] (%)	Fd [c] (%)	Sx [d] (%)	Bl [e] (%)					
GEL CAP	2	37.5	34.4	25.0	3.1	800	1.5	123.9	1.3	1.0
Girdling	2	54.5	6.8	22.7	15.9	1 100	1.5	96.6	1.9	1.0
Hack-and-squirt	2	48.4	25.8	19.4	6.5	775	2.2	205.8	1.4	1.0
EZJECT	2	58.1	29.0	6.5	6.5	775	0.7	82.5	2.3	1.0
Weighted averages		50.0	22.5	18.8	8.7	860	1.6	145.3	1.7	1.0

[a] This table contains data for Kelowna Block 2 only.
[b] Lodgepole pine.
[c] Interior Douglas-fir.
[d] Hybrid white spruce.
[e] Subalpine fir.

nology as well as the standard methods presently in use. The girdling and hack-and-squirt methods were used as industry standards to form a basis of comparison for the GEL CAP and EZJECT methods. Hack-and-squirt, GEL CAP, and EZJECT systems are methods of applying the herbicide glyphosate to the target tree through bark incisions, while girdling is a strictly manual treatment involving the removal of a ring of bark from the circumference of the target tree. Product labels are provided in Appendix III, and the tools are described in more detail in Appendix IV. In this study, only the aspen trees were treated. Because they were difficult to treat, the small diameter aspen (less than 2 cm) were usually broken off in the girdling, GEL CAP, and EZJECT treatments, and cut off in the hack-and-squirt treatment with the cut stump treated.

Girdling

FERIC chose the Vredenburg girdling tool for this project. This tool was manufactured in Utah but is presently unavailable commercially because the original manufacturer is no longer in business. The tools used for this study were borrowed from the Port McNeill Division of MacMillan Bloedel Limited where they have been in use since 1983.

The Vredenburg girdling tool resembles a large pair of toothed pliers (Figure 3). The sharp teeth and rakers on the inner surface cut a ring around the tree when the pliers are closed and rotated about the stem (Figure 4). A complete review of this tool is presented in Conway-Brown (1984).

Figure 3, left and right. Vredenburg girdling tools. Note toothed inner surface.

Figure 4. Operator using Vredenburg girdling tool for aspen control.

Hack-and-Squirt

A hatchet and a Du Pont disposable spotgun with a reservoir were selected for the hack-and-squirt portion of this study (Figure 5). The spotgun allowed a pre-measured dose (1 mL per 5 cm of stem diameter) of a 50% VISION®[11] solution to be administered to the hatchet frills on the aspen stems (Figure 6). There are numerous other tools that would also provide the desired treatment.

GEL CAP

The GEL CAP system requires a cordless drill to apply the capsules to the target trees. A Makita cordless drill was used to apply the GEL CAP capsules at a rate of one capsule per 6 cm of stem diameter (Figures 7 and 8). Pace Chemicals Ltd. supplied FERIC with the plastic capsules containing a gelled glyphosate solution. Specifications and description of the Makita drill are provided in Appendix IV.

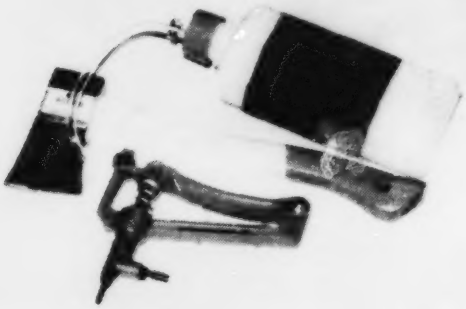


Figure 5. Hatchet and Du Pont disposable spotgun for hack-and-squirt treatment.

EZJECT

Monsanto Canada, Inc. supplied two EZJECT lances and capsules containing a glyphosate salt (Figures 9 and 10). The lance design is still in the development stages. Treatment rate was one capsule per 5 cm of diameter.

The three chemical methods are also briefly discussed by Conway-Brown (1984); however, at the time of his paper, the GEL CAP and the EZJECT methods had not been fully developed and were not in commercial production. His descriptions of these two application methods are not accurate, but they do present an overall view of stem injection systems and their advantages over other chemical vegetation-control methods. A more updated discussion of the four methods examined in this study is presented by Bancroft (1989). Because the herbicide used with the EZJECT and GEL CAP methods is encapsulated, these two methods are unlikely to chemically contaminate the crew or environment.

OPERATOR TRAINING AND EXPERIENCE

FERIC hired an experienced silvicultural contractor who had been extensively involved with vegetation management research projects in the Prince George Forest

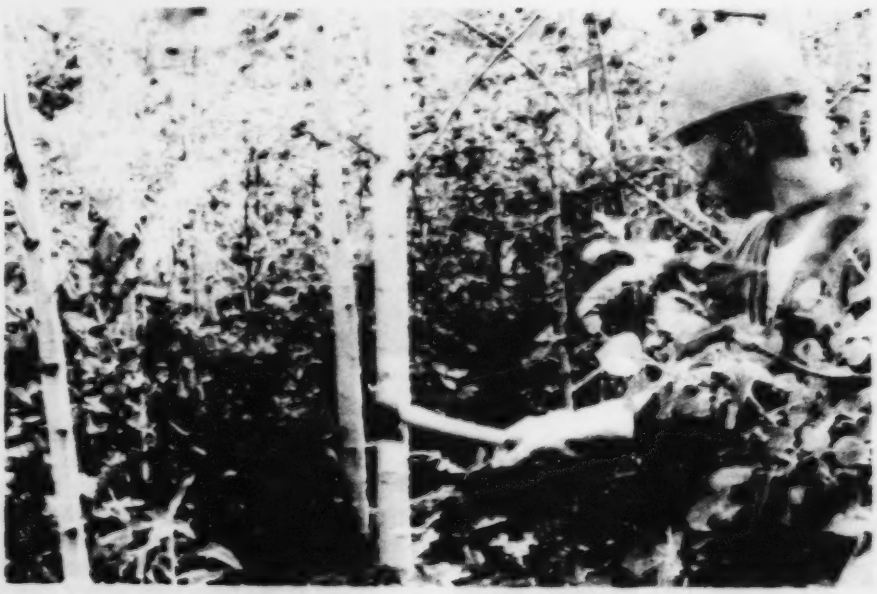


Figure 6. Operator using hack-and-squirt method on aspen.

[11] VISION® is a registered trademark of Monsanto Company U.S.A. Monsanto Canada Inc. is a registered user.

Figure 7. Operator using GEL CAP method on aspen.

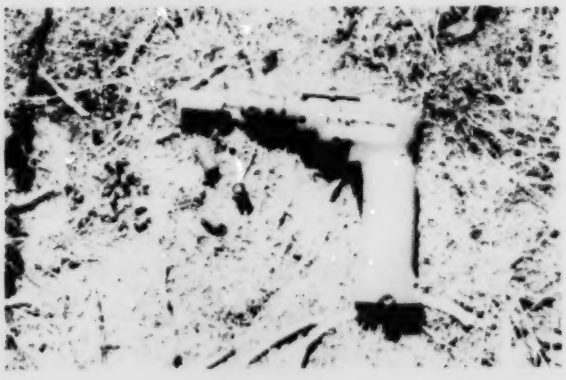


Figure 8. GEL CAP capsules and Makita cordless drill with applicator bit.

Region. The contractor has a forestry degree and has had previous experience with hack-and-squirt and VELPAR L®[12] ground applications. The contractor provided an additional inexperienced person to assist with the treatments for this project. Both operators were enthusiastic and highly motivated.

The two operators were instructed in the use of the tools for all four treatments and were allowed time to become more familiar with the tools to perfect their handling skills. During this preparation period, the operators were continually monitored by FERIC to ensure that they were very familiar with the study requirements.

[12] VELPAR L® is a registered trademark of Du Pont Canada Inc.

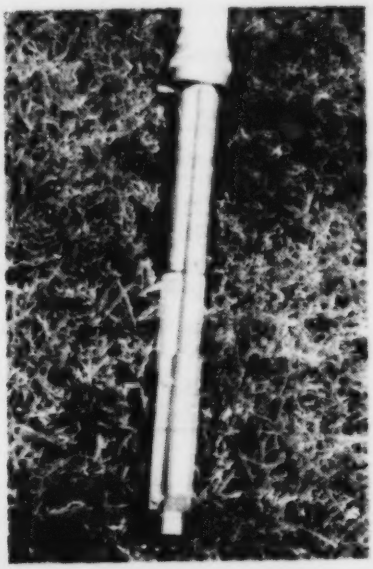
RESULTS AND DISCUSSION

Productivity by Treatment and Statistical Analysis

Treatment of the plots, and time and motion studies were completed in August 1989. The four methods varied considerably in their relative rankings when the productivities, both in terms of ha/manday and time/tree, were examined. GEL CAP was the most productive of the four methods at the Prince George site (0.31 ha/manday), while EZJECT and girdling ranked higher at the Kelowna site with productivities of 0.27 and 0.26 ha/manday, respectively. However, the differences in productivities of EZJECT, girdling, and GEL CAP at the Kelowna site were not very large. Productivities for the treatments are presented in Table 9.

In terms of time/tree, GEL CAP was fastest at both sites, although, again at the Kelowna location, the differences between GEL CAP, EZJECT, and girdling were small. In all cases, hack-and-squirt was the slowest method on a per tree basis.

Analysis of variance (ANOVA), using hourly productivities, showed significant differences in productivity between the treatment methods and the operators; the hourly productivities were also affected by the number of aspen stems in each plot (Table 10). There were no significant interactions between the operators and the treatments although one operator consistently had greater productivity with EZJECT than the other operator. Other analyses showed that the total number of trees (aspen and other species) per plot had an effect on the productivity.



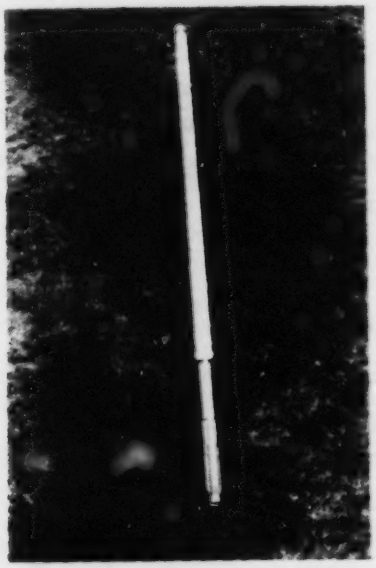


Figure 9, left and right. EZJECT lance loaded with 0.22 calibre shells.

Figure 10. Operator using EZJECT to apply glyphosate to aspen.

An earlier study by Hedin compared the use of the Vredenburg girdling tool and hack-and-squirt in red alder on Vancouver Island (Table 11).[13] She found that girdling provided similar, if not better, productivity than hack-and-squirt for stem sizes of 4-cm to 16-cm. Hedin examined average treatment times per tree on these diameters. For stems less than 4-cm, both methods were similar at 0.14 minutes. For stems 4-cm to 12-cm, girdling was faster than hack-and-squirt, i.e. 0.15 and 0.21 min for girdling compared to 0.23 and 0.31 for hack-and-squirt. She measured overall productivities of 0.42 ha/manday for girdling and 0.46 ha/manday for hack-and-squirt.

[13] I.B. Hedin, 1983; "A comparison of productivity of girdling and hack-and-squirt techniques in conifer release"; FERIC Interim Report IR-383-2, unpublished.

Table 9. Single-Stem Treatment Productivities[a]

Treatment method	Block	Prince George				Kelowna			
		Block averages		Treatment averages		Block averages		Treatment averages	
		Ha/manday	Min/tree	Ha/manday	Min/tree	Ha/manday	Min/tree	Ha/manday	Min/tree
EZJECT	1	0.35	0.32	0.27	0.29	0.30	0.23	0.27	0.22
	2	0.20	0.27			0.23	0.21		
Girdling	1	0.29	0.30	0.24	0.23	0.28	0.24	0.26	0.21
	2	0.20	0.16			0.24	0.19		
Hack-and-squirt	1	0.29	0.35	0.30	0.31	0.10	0.48	0.10	0.44
	2	0.30	0.27			0.10	0.40		
GEL CAP	1	0.43	0.16	0.31	0.16	0.25	0.25	0.23	0.21
	2	0.18	0.15			0.22	0.17		

[a] Productivities based on an 8-h manday with 75% utilization.

Table 10. Analysis of Variance for Productivity Results

Source	df	Probability >F
Site	1	0.1518 [b]
Site x block	2	0.2449 [b]
Treatment	3	0.0094 [a]
Operator	1	0.0089 [a]
Treatment x operator	3	0.5040 [b]
Aspen trees per plot	1	0.0001 [a]
Error	52	
Corrected total	63	

[a] Highly significant, probability (of being due to chance) ≤1%.
[b] Not significant, probability (of being due to chance) >5%.

Table 11. Comparison of Girdling and Hack-and-Squirt Treatments[a]

	Diameter at breast height		
	<4 cm	4-<8 cm	8-<12 cm
Average number of stems/ha			
Girdling	1 204	1 408	900
Hack-and-squirt	153	1 540	1 280
Average treatment time (min)			
Girdling	0.14	0.15	0.21
Hack-and-squirt	0.14	0.23	0.31
Standard deviation			
Girdling	0.079	0.063	0.098
Hack-and-squirt	0.050	0.086	0.103

[a] Excerpt from I.B. Hedin, 1983; "A comparison of productivity of girdling and hack-and-squirt techniques in conifer release"; FERIC Interim Report IR-383-2, unpublished.

Cost Estimates

Insufficient data are available on the purchase price and expected life of the tools because many are not yet commercially available. Therefore, a complete costing of the four methods is not possible, and the fixed cost of equipment purchase has been excluded from the calculations. The treatment cost has been calculated for each method based only on the labour and chemical components using the productivities estimated in this study.

The labour costs were determined using a contract rate of $10/h plus a 35% wage benefit loading, and based on the productivities achieved in this study. The chemical costs were calculated from the purchase costs for each of the formulations—VISION at $13.25/L, GEL CAP at $180.50/1000 capsules, and EZJECT at $60/1000 shells—and the required amounts of chemical based on the diameter distributions of the aspen stems. The estimated costs are presented in Table 12.

Of the four methods, girdling was the least expensive method, at $440/ha, because it required no chemical. Of the three chemical methods, the GEL CAP system was the most expensive, costing $1904/ha because of the high price of the capsules. The EZJECT system was substantially less expensive, at $1019/ha, while the hack-and-squirt method was the least costly of the injection methods at $766/ha. From an industry survey, Bancroft (1989) quotes costs of $0.10-0.65/stem (girdling), $2.90/stem (Wee-Do (EZJECT)), $2.33/stem (GEL CAP), and $0.75-3.00/stem (hack-and-squirt) for preharvest treatments of aspen which had larger diameters and subsequently higher treatment costs per tree than in this study. Table 13 presents a comparison of the relative costs for the two studies; based on the girdling treatments, the costs for hack-and-squirt and GEL CAP were within Bancroft's ranges, and the cost for EZJECT was below Bancroft's range. However, in all cases, if the purchase costs for the equipment are included in FERIC's assessment, the relative costs for the treatment in both studies would be similar, although FERIC's

Table 12. Treatment Costs

Treatment method	Block	Prince George Aspen trees/ha (no.)	Prince George Cost Labour [a] ($/ha)	Prince George Cost Herbicide ($/ha)	Prince George Cost Total ($/ha)	Kelowna Aspen trees/ha (no.)	Kelowna Cost Labour [a] ($/ha)	Kelowna Cost Herbicide ($/ha)	Kelowna Cost Total ($/ha)	Treatment averages ($/ha)
EZJBCT	1	5 830	310	418	728	6 400	361	596	957	1 019
	2	8 130	546	564	1 111	12 030	464	815	1 278	
Girdling	1	5 000	370	n/a	370	5 800	387	n/a	387	440
	2	7 800	546	n/a	546	9 700	457	n/a	457	
Hack-and-squirt	1	3 980	368	31	399	7 550	1 046	69	1 115	766
	2	7 530	360	58	418	11 250	1 049	83	1 131	
GEL CAP	1	4 330	250	926	1 176	5 700	437	1 391	1 828	1 904
	2	7 830	604	1 697	2 300	8 950	499	1 814	2 313	

[a] Labour costs based on daily productivities estimated in this study.

Table 13. Comparison of Relative Costs of the Four Treatments Based on Data from FERIC and Bancroft (1989)

Treatment	Cost of treatments relative to girdling: FERIC	Bancroft
EZJBCT	2.0	4.5 - 29.0
Girdling	1	1
Hack-and-squirt	1.6	1.2 - 30.0
GEL CAP	4.6	3.6 - 23.3

would likely be in the lower part of Bancroft's ranges. Costs for motor-manual treatments using clearing saws usually fall into the $350-$800/ha range.[14] The costs of the EZJBCT and GEL CAP systems are expected to drop as the methods become more commercially available and widely used.

Post-Treatment Evaluations

Following the treatment, the tagged trees were re-examined for quality of treatment. During these assessments, the treatment quality for each sample tree was ranked from 1 to 5, with a score of "1" meaning the desired quality was achieved and "5" meaning the tree was untreated. Girdling was assessed for completeness of the girdle, and hack-and-squirt for the completeness of the frill and the distribution of VISION herbicide around the tree. GEL CAP and EZJBCT were assessed for how firmly the capsules or shells were implanted in the aspen stems plus the number of successful and unsuccessful attempts at implanting the capsules or the shells. Trees with treatment codes of "2" or lower were considered successfully treated and are expected to die.

Generally, the treatment quality was good (Table 14). The overall percentage of acceptably treated trees, i.e. with treatment codes less than "2," was 94% or higher in each of the treatment units. However, the two Prince George hack-and-squirt plots were exceptions, with 84% and 90% for Block 1 and Block 2 respectively. The plots in these two blocks had numerous missed and incompletely treated trees. The average quality codes for the assessed trees show similar trends. EZJBCT, girdling, and GEL CAP had similar codes of 1.2, 1.1, and 1.1 respectively, while the hack-and-squirt treatments had an average code of 1.4. This variation was again related to the Prince George hack-and-squirt blocks which had codes of 1.8 and 1.6 for Block 1 and Block 2 respectively. The causes of the missed treatments and incomplete frilling in the hack-and-squirt treatments were not apparent; however, on average, less time was spent treating each tree in the hack-and-squirt plots at Prince George than in the same treatments at the Kelowna location.

The EZJBCT had the lowest average treatment height—approximately one-third the height of the other treatments. This was a result of the reach afforded by the lance. The angle of the head allows the EZJBCT to work most effectively when implanting shells at heights between 25 and 50 cm where the head surface has maximum contact with the aspen stem. All of the methods provided treatment heights that were below the lowest live limbs, a factor which can affect efficacy particularly with girdling treatments.

Figures 11 through 14 illustrate trees treated by the four methods.

[14] Costs derived from: Holmsen (1988), and J. Perry, 1987; "An assessment of manual brush control in the Cariboo Forest Region"; BCMOFL, unpublished report.

Table 14. Evaluation of Treatment Quality

Treatment method	Block	Overall average		Prince George			Kelowna		
				Treatment		Trees successfully treated (%)	Treatment		Trees successfully treated (%)
		Height (cm)	Code	Height (cm)	Code		Height (cm)	Code	
EZJBCT	1	31.6	1.2	32.5	1.1	100	37.9	1.1	100
	2			22.6	1.1	97	32.7	1.3	99
Girdling	1	94.7	1.1	87.3	1.2	100	92.6	1.1	97
	2			89.5	1.1	95	101.8	1.3	94
Hack-and-squirt	1	96.2	1.4	80.8	1.8	84	104.1	1.0	100
	2			98.8	1.6	90	93.6	1.1	99
GEL CAP	1	99.4	1.1	98.7	1.2	96	101.3	1.1	98
	2			95.4	1.1	98	98.4	1.1	98

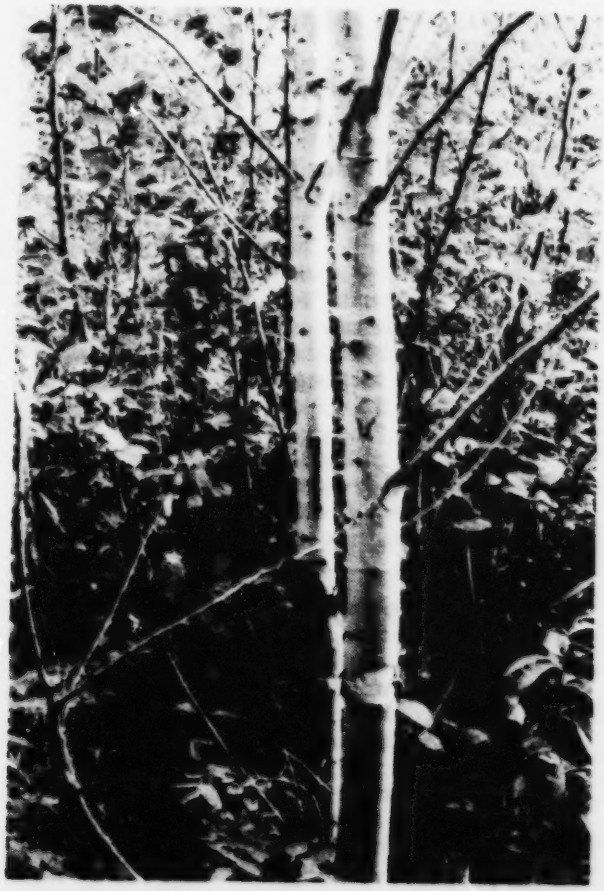


Figure 11. Girdled stem.

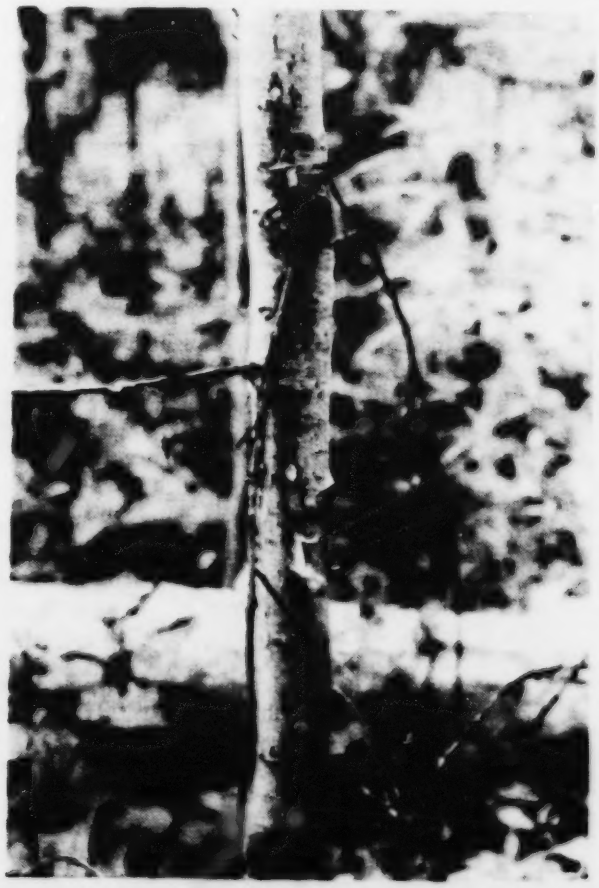


Figure 12. Aspen treated by EZJBCT method.

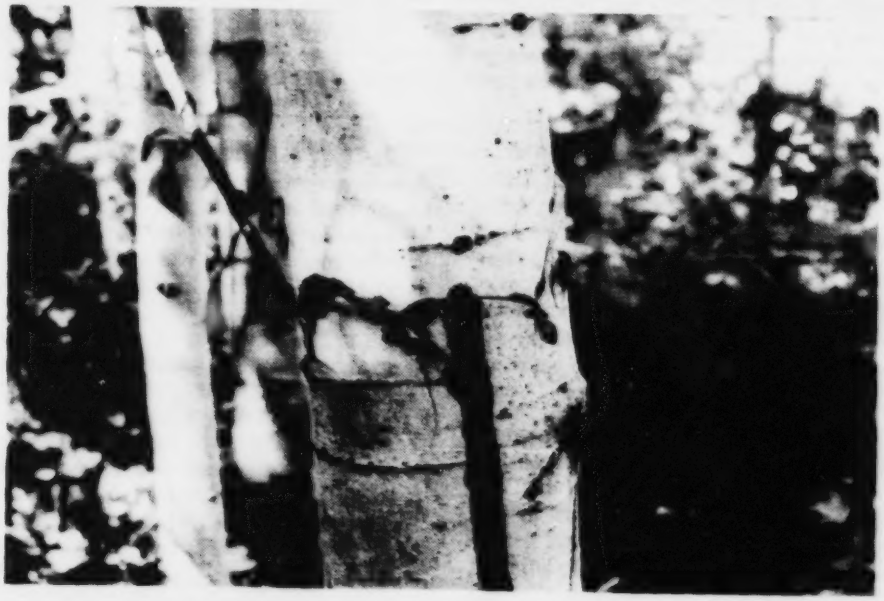


Figure 13. Aspen treated by hack-and-squirt method.

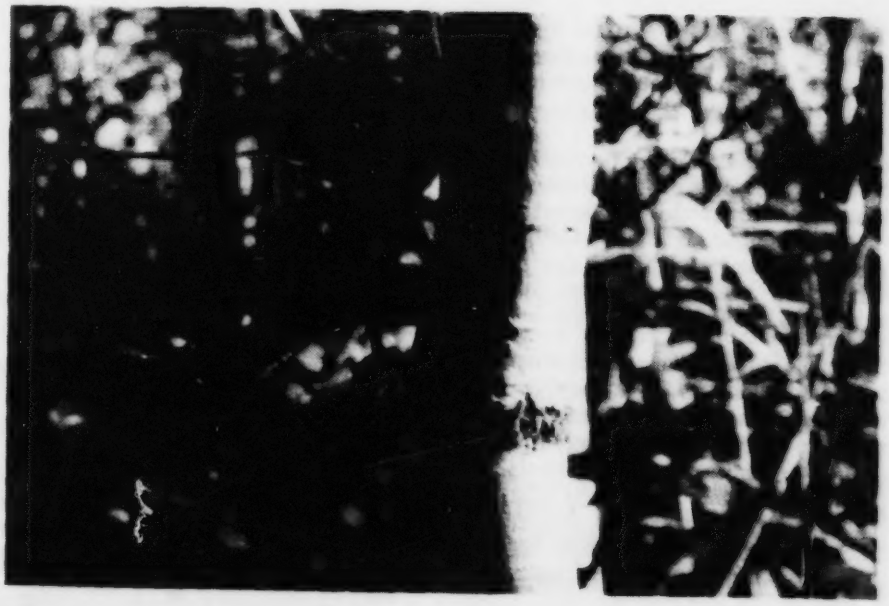


Figure 14. Aspen treated by GEL CAP method.

Table 15 compares the success of implanting the shells (EZJECT) with capsules (GEL CAP).

GEL CAP, at both the Prince George and Kelowna locations, and EZJECT, at Prince George only, had similar success rates, i.e. greater than 95 percent. The EZJECT treatment at Kelowna had lower rates of successful injections, particularly in Block 2 where many of the shells were loose and easily brushed out of the aspen stems; loose shells were common at all sites when small stem diameters (less than 2 cm) were treated. During application, these stems bent under pressure from the lance, and the shells were not firmly seated in the stem. Additionally, in Block 2 at the Kelowna location, the vegetation was wet; when the lance was pressed against the smaller aspen stems, it slid down, causing the shells to be loosely injected.

Table 15. Evaluation of Treatment Attempts for EZJECT and GEL CAP

Treatment method	Block	Averages for all sites: Average attempts/tree (no.)	Averages for all sites: Distribution of attempts: Successful (%)	Averages for all sites: Distribution of attempts: Unsuccessful (%)	Prince George: Average attempts/tree (no.)	Prince George: Distribution of attempts: Successful (%)	Prince George: Distribution of attempts: Unsuccessful (%)	Kelowna: Average attempts/tree (no.)	Kelowna: Distribution of attempts: Successful (%)	Kelowna: Distribution of attempts: Unsuccessful (%)
EZJECT	1	1.2	93	7	1.2	98	2	1.3	92	8
	2				1.1	98	2	1.2	86	14
GEL CAP	1	1.1	98	2	1.2	96	4	1.2	98	2
	2				1.1	99	1	1.0	100	0

Operator Comments on Use of the Tools

The most important things for an operator or contractor to consider when choosing a particular tool are:

- Worker safety
- Ease of use
- Reliability of equipment
- Consistency of treatment
- Risk associated with the capital investment in the tool

The two operators evaluated each tool on the basis of these categories and ranked them from 1 to 4 relative to each other. A score of "1" indicates the top-ranked method while "4" is the lowest. These rankings are presented in Table 16.

Worker Safety. Risk of physical injury from the use of a tool or exposure to the pesticide are the main concerns in worker safety. The operators in this study felt that the GEL CAP and the girdling tool were the safest of the four methods. There is very little risk of exposure to the glyphosate in the capsules unless they are warmed to the extent that the gel softens and leaks.

The girdling tool may lead to repetitive-motion injuries, as can hack-and-squirt and EZJECT. Hack-and-squirt was considered the least safe since it has the greatest risk of chemical exposure, as well as danger of injury from the hatchet. Bancroft (1989) indicated that respondents to a questionnaire perceived a higher risk to their safety for girdling than glyphosate application due primarily to risk of injury; however, he did not differentiate between the herbicide methods when discussing the safety risk and, therefore, none of the four methods were viewed as unsafe. In the same report, Bancroft also noted that the Workers' Compensation Board does not distinguish manual methods from chemical methods in determining the rate structures for their use.

Ease of Use. All of the tools were relatively easy to use although the three herbicide methods required some training to allow the operators to become familiar with the application methods and rates. The main drawback of the girdling and the hack-and-squirt methods is that they require the operator to be physically strong to maintain an adequate productivity level.

Table 16. Ranking of Four Treatment Methods

	EZJECT	Girdling	Hack-and-squirt	GEL CAP
Worker safety	3	2	4	1
Ease of use	3	2	4	1
Reliability of equipment	4	1	3	1
Consistency of treatment	4	1	3	1
Risk of capital investment	4	1	1	3
Overall ranking	4	1	3	1

Reliability of Equipment. FERIC did not examine the durability of the tools, and as many of them were recently developed, it was difficult to determine their life expectancies. During the productivity studies, short-term reliability of the tools was examined. From this perspective, the GEL CAP method and the girdling tools were more reliable, although it is not evident how long the Makita drills will stand up to constant use. The EZJECT model used in this study was unreliable; it jammed frequently and was difficult to repair in the field because it has a number of small parts, such as snap rings and springs, that are easily lost. Further modifications of this tool may improve its reliability.

The Vredenburg girdling tools that FERIC used were borrowed from MacMillan Bloedel Limited and had been in use since 1983. Maintenance of these girdling tools consisted of sharpening the teeth and rakers. The tools had undergone some minor modifications and repairs, but were in very good condition. These tools appeared to be the most robust and simple of the tools examined in this study.

The hatchet used for hack-and-squirt can be expected to last some time if maintained. The Du Pont disposable spotgun was plastic and probably would have a short life under regular operational use; however, a more durable version may be purchased for approximately $100, or another less expensive dispensing method such as a squirt bottle may be used.

Consistency of Treatment. The GEL CAP and the girdling tools provided the most consistent treatment results during the study. The hack-and-squirt results exhibited variation between workers in the way that the frill was made and the chemical injected. The EZJECT

was the least consistent of the tools with shells frequently being loosely or improperly implanted in the stem. The operators also experienced difficulty with implanting shells in wet stems because the EZJECT lance would slip.

Risk Associated with Capital Investment in the Tool. The girdling and the hack-and-squirt tools are the least expensive tools to purchase and, therefore, have the lowest perceived risk associated with their purchase. The EZJECT, at this time, is likely the most expensive tool to purchase. The purchase of this tool would be difficult to justify based only on the productivity performance and reliability of the prototype used in this study; however, commercial models of the EZJECT lance will probably overcome the problems experienced during this project and provide a more reliable, and therefore, more economical tool. At the time of this report, numerous modifications had been made to improve the lance. The GEL CAP equipment is also fairly expensive, but the Makita drills can also be used for their intended purpose and have potential resale value. These latter two tools should also be considered on the basis of environmental impact since they introduce very little herbicide to the environment.

Comparison of Treatment Times by Diameter Classes

Prior to completing an analysis of the relationship between stem diameter and treatment time, scatter diagrams of the data were plotted for each block-treatment-operator combination. In most cases, there was no correlation, or the diameter appeared to have no effect on the treatment time. The hack-and-squirt treatments at the Prince George site and Block 1 at the Kelowna location exhibited a low positive correlation between the diameters and treatment times. Because of the lack of consistent results, no further analyses were undertaken.

SUMMARY AND CONCLUSIONS

FERIC measured productivities ranging from 0.10 to 0.43 ha/manday based on an 8-h/day at 75% utilization. The four methods varied in their relative rankings; GEL CAP was the most productive at Prince George with an average of 0.31 ha/manday, while EZJECT and girdling had higher productivities, 0.27 and 0.26 ha/manday, respectively, at Kelowna. Treatment costs for this project ranged form $370 to $2313/ha based on the chemical and labour components, and excluding the equipment purchase and maintenance costs. In general, the girdling treatment was the least expensive, $370 to $546/ha while the GEL CAP method was the most expensive, $1176 to $2313/ha. The high cost of the GEL CAP method was attributed to the product price of $0.18 per capsule. Treatment costs of the EZJECT and GEL CAP systems can be expected to drop when the two methods become more commercially available.

Post-treatment assessments indicated that all of the methods provided good treatment quality, although the Prince George hack-and-squirt treatment had a slightly lower percentage of correctly treated trees. Of the two capsule methods, the EZJECT treatments at Kelowna needed a higher number of attempted injections per stem to achieve the required number of successful injections; many of the shells were loose or even fell out of the stems after being implanted, particularly when the stems were less than 2 cm in diameter at the base.

The operator ranked the GEL CAP and girdling methods highest overall in terms of worker safety, ease of use, reliability of equipment, consistency of treatment, and risk of capital investment. Future evaluations of the treated trees will indicate the efficacy of each treatment in terms of mortality; this will determine the long-term cost effectiveness associated with each treatment.

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APPENDIX I

Experimental Design and Block Layout

At each location, FERIC established two treatment blocks containing sixteen 10-m x 10-m plots (Figures I-1 and I-2). The four treatments—girdling, GEL CAP, hack-and-squirt, and EZJECT—and the two operators, were randomly assigned to the plots.

FERIC selected a subsample of four plots per block (one in each treatment method) for vegetation and crop-tree assessments. Vegetation assessments included the collection of information on species, size, vigour, and distribution according to study methods described by Whitehead.[1] Within these plots, a survival plot (radius 3.99 m) was established for the mapping and assessment of conifer crop trees.

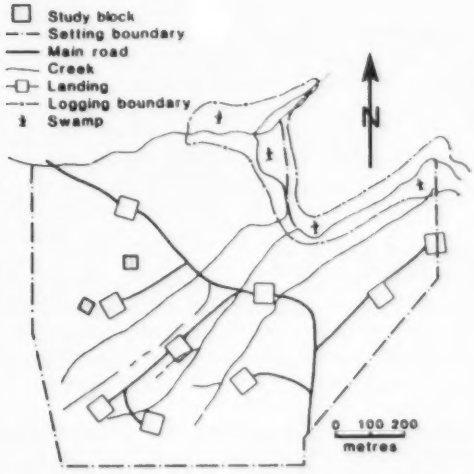

Figure I-1. Treatment plots at Prince George, Lamb Lake site.

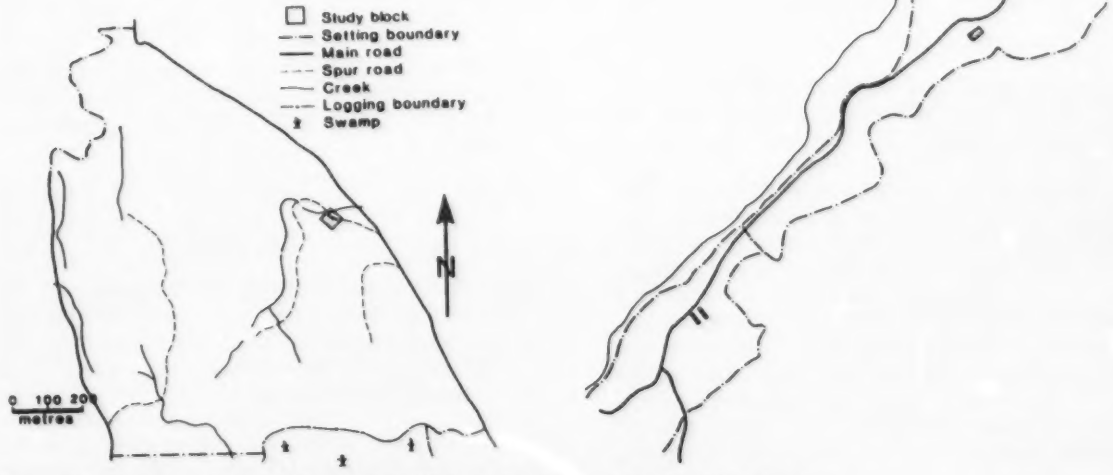

Figure I-2. Treatment plots at Kelowna; left—Bighorn Creek site, right—Lambly Lake site.

[1] R.J. Whitehead, 1985, "Description of plant community response to vegetation management treatments"; Canadian Forestry Service, unpublished draft report.

APPENDIX II

Species List[1]

Latin name	Common Name	Location[2]
Abies lasiocarpa	subalpine fir	K
Acer glabrum	Douglas maple	K
Achillea millefolium	yarrow	PG
Actaea rubra	baneberry	K
Alnus sinuata	Sitka alder	PG
Alnus viridis	green alder	K
Amelanchier alnifolia	saskatoon	PG, K
Aralia nudicaulis	wild sarsaparilla	PG, K
Arctostaphylos uva-ursi	kinnikinnick	K
Arnica cordifolia	heart-leaved arnica	PG, K
Arnica latifolia	mountain arnica	PG
Aster conspicuous	showy aster	PG
Calamagrostis rubescens	pinegrass	PG, K
Castilleja rhexifolia	alpine paintbursh	K
Chimaphila umbellata	prince's pine	PG, K
Clintonia uniflora	queen's cup	PG, K
Cornus canadensis	bunchberry	PG, K
Cornus sericea	red-osier dogwood	K
Disporum hookeri	Hooker's fairybells	PG, K
Epilobium angustifolium	fireweed	PG, K
Fragaria virginiana	wild strawberry	PG
Galium triflorum	sweet-scented bedstraw	PG, K
Goodyera oblongifloia	rattlesnake-plantain	PG, K
Gymnocarpium dryopteris	oak fern	PG
Hieracium albiflorum	white-flowered hawkweed	K
Hieracium cynoglossides	hound's-tongue hawkweed	PG
Lilium columbianum	tiger lily	K
Linnea borealis	twinflower	PG, K
Lonicera involucrata	black twinberry	PG, K
Lonicera utahensis	Utah honeysuckle	K
Mahonia aquifolium	tall Oregon-grape	K
Mitella breweri	Brewer's mitrewort	PG
Monese uniflora	single delight	PG, K
Oplopanax horridus	devil's club	K
Osmirhiza chilensis	mountain sweet-cicely	PG, K
Paxistima myrsinites	falsebox	K
Pedicularis bracteosa	bracted lousewort	K
Petasites palmatus	palmate coltsfoot	PG
Picea glauca x engelmannii	hybrid white spruce	K
Picea glauca	white spruce	PG

[1] D. Meidinger, 1987, "Recommended vernacular names for common plants of British Columbia"; B.C. Ministry of Forests and Lands, draft report.

[2] PG - Prince George; K - Kelowna

Latin name	Common name	Location[2]
Pinus contorta	lodgepole pine	PG, K
Populus tremuloides	trembling aspen	PG, K
Pseudotsuga menziesii var. glauca	interior Douglas-fir	K
Pyrola asarifolia	pink wintergreen	PG, K
Ribes lacustre	black gooseberry	PG, K
Ribes viscosissimum	sticky currant	K
Rosa spp.	rose	PG, K
Rubus idaeus	red raspberry	PG, K
Rubus parviflorus	thimbleberry	PG, K
Rubus pedatus	five-leaved bramble	PG, K
Salix spp.	willow	PG, K
Shepherdia canadensis	soopolallie	PG, K
Smilacena racemosa	false Solomon's-seal	PG, K
Smilacena stellata	star-flowered false Solomon's-seal	K
Sorbus sitchensis	Sitka mountain-ash	K
Spirea betulifolia	birch-leaved spirea	PG, K
Symphoricarpus albus	common snowberry	K
Thalictrum occidentale	western meadowrue	K
Tiarella unifoliata	one-leaved foamflower	K
Vaccinium spp.	blueberry	PG, K
Viburnum edule	highbush cranberry	PG

[2] PG - Prince George; K - Kelowna.

APPENDIX III

Labels for Treatment Methods and Chemicals

At the time of writing, all appendix information was believed current and accurate. However, this information may be subject to change by manufacturers subsequent to the report being published. For the most current information check with the manufacturer.

VISION

SELECTIVE HERBICIDE FOR SILVICULTURAL SITES

Monsanto

RESTRICTED

CAUTION

IRRITANT

Water soluble herbicide for silvicultural sites

REGISTRATION NO. 19899 PEST CONTROL PRODUCTS ACT

GUARANTEE Glyphosate 356 g/L present as isopropylamine salt

READ THE LABEL BEFORE USING

1987 BST 10-004-21

(FRANÇAIS AU VERSO)

AVOID CONTACT WITH FOLIAGE, GREEN STEMS, OR FRUIT OF NON-TARGET CROPS, DESIRABLE PLANTS AND TREES SINCE DAMAGE TO THESE PLANTS MAY RESULT

PRECAUTION!

Keep out of reach of children.

MAY CAUSE EYE IRRITATION

HARMFUL IF SWALLOWED

Avoid contact with eyes or prolonged contact with skin.

FIRST AID: In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Call a physician. Flush skin with water.

Read NOTICE before buying or using. If notice terms are not acceptable, return at once unopened.

Canadian Patent 936,865
Not for reformulation or repackaging

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Monsanto Canada Inc. proposed registered user
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MONSANTO CANADA INC.
Streetsville, P.O. Box 787
Mississauga, Ontario L5M 2C4
Montreal • Winnipeg • Regina • Saskatoon • Calgary • Edmonton • Vancouver

IN CASE OF EMERGENCY INVOLVING THIS PRODUCT, Call Collect, day or night, (314) 694-4000.

GENERAL INFORMATION

When applied as directed under conditions described, this product controls undesirable vegetation listed on this label. This product also suppresses or controls undesirable vegetation listed on this label when applied at recommended rates for release of established coniferous species listed in the "Conifer Release" section of this label.

This product may be applied using aerial and ground spray equipment for silvicultural site preparation, rights-of-ways, and conifer release and ground spray equipment for forest road side vegetation management and forest tree planting nurseries. Woody vegetation may be controlled by injection or frill application of this product. See the "Mixing" and "Applications Instructions" sections of this label for information on how to properly apply this product.

For herbaceous weeds, woody brush, and trees controlled, see the "Vegetation Controlled" section of this label.

For specific site preparation instructions, see the "Site Preparation, Forest Roadside and Rights-of-way Vegetation Management" section of the label.

For specific conifer release instructions see the "Conifer Release" section of this label.

Treatments should not be made to trees or brush after fall leaf drop has begun.

For specific forest tree planting nurseries instructions see the "Forest Tree Planting Nurseries" section of this label.

For specific injection and frill applications instructions, see the "Injection and Frill Applications" section of this label.

This product moves through the plant from the point of foliage contact to and into the root system. Visible effects on most annual weeds occur within 2 to 4 days, but on most susceptible perennial weeds, trees and woody brush, may not occur until 7 to 14 days. Extremely cool or cloudy weather at treatment time may slow down activity of this product and delay visual effects or control. Visible effects are a gradual wilting and yellowing of the plant which advance to complete browning of above-ground growth and deterioration of underground plant parts.

Delay application until vegetation has emerged to the stages described for control of such vegetation under the "Vegetation Controlled" section of this label to provide adequate leaf surface to receive the spray. Unemerged plants arising from underground rhizomes or root stocks of perennials will not be affected by the spray and will continue to grow. For this reason best control of most perennial herbaceous vegetation is obtained when treatment is made at late growth stages approaching maturity.

Always use the higher rate of this product per hectare within the recommended range on hard to control species or when vegetation growth is heavy or dense.

Do not treat vegetation under poor growing conditions such as drought stress, disease or insect damage as reduced vegetation control may result. Reduced results may also occur when treating vegetation heavily covered with dust.

Rainfall occurring within 6 hours after application may reduce effectiveness. Heavy rainfall within 2 hours after application may wash the product off the foliage and a repeat treatment may be required.

Do not mix with any surfactant, pesticide, herbicide or any other material other than water unless specified in this label.

For best results spray coverage should be uniform and complete. Do not spray to wet foliage to the point of runoff.

ATTENTION

AVOID DRIFT. EXTREME CARE MUST BE USED WHEN APPLYING THIS PRODUCT TO PREVENT INJURING DESIRABLE PLANTS AND CROPS. Do not allow spray mist to drift, since even minute quantities of spray can cause severe damage or destruction to nearby crops, plants or other areas on which treatment is not intended, or may cause other unintended consequences. Do not apply when wind is gusty or in excess of 8 km/h or when other conditions, including lesser wind velocities, will allow drift to occur. When spraying, avoid combinations of pressure and nozzle type that will result in fine particles (dust) which are more likely to drift.

NOTE: Use of this product in any manner not consistent with this label may result in injury to persons, animals or crops, or other unintended consequences. Keep container closed to prevent spills and contamination.

Clean sprayer parts immediately after using this product by thoroughly flushing with water. Do not contaminate water sources by disposal of wastes or cleaning of equipment.

MIXING INSTRUCTIONS

This product mixes readily with water.

For ground, aerial or industrial type sprayers, fill the spray tank with one half the required amount of water. Add the proper amount of herbicide (see "Directions for Use" and "Vegetation Controlled" sections of the label) and mix well before adding the remaining portion of water. Placing the filling hose below the surface of the liquid solution will prevent excessive foaming. Removing hose from tank immediately will avoid back siphoning into water source. Use of mechanical agitators may cause excessive foaming. By-pass lines should terminate at the bottom of the tank. For use in knapsack sprayers, it is suggested that the proper amounts of this herbicide be mixed with water in a larger container. Fill sprayer with the mixed solution.

NOTE: REDUCED RESULTS MAY OCCUR IF WATER CONTAINING SOIL IS USED, SUCH AS WATER FROM PONDS AND UNLINED DITCHES.

APPLICATION INSTRUCTIONS

APPLY THESE SPRAY SOLUTIONS IN PROPERLY MAINTAINED AND CALIBRATED EQUIPMENT CAPABLE OF DELIVERING DESIRED VOLUMES.

HAND GUN APPLICATIONS SHOULD BE PROPERLY DIRECTED TO AVOID SPRAYING DESIRABLE PLANTS.

AVOID DRIFT—Drift may cause damage to any vegetation contacted for which treatment is not intended. Applications in wind conditions in excess of 8 km/h are not recommended.

To prevent injury to adjacent vegetation appropriate buffer zones must be maintained.

Do not apply directly to any body of water populated with fish or used for domestic purposes. Do not use in areas where adverse impact on domestic water or aquatic species is likely.

AERIAL EQUIPMENT

Use the recommended rates of this herbicide in 30 to 100 L of water per hectare. See "Vegetation Controlled" section of this label for specific rates. As density of vegetation increases, spray volume should be increased within the recommended range to ensure complete coverage.

Coarse sprays are less likely to drift; therefore do not use nozzles or nozzle configurations which dispense spray as fine spray droplets. Do not angle nozzles forward into the airstream and do not increase spray volume by increasing nozzle pressure.

Ensure uniform application—To avoid streaked, uneven or overlapped application, use appropriate marking devices. The use of a spotter plane is recommended.

Thoroughly wash aircraft, especially landing gear, after each day of spraying to remove residues of this product accumulated during spraying or from spills. PROLONGED EXPOSURE OF THIS PRODUCT TO UNCOATED STEEL SURFACES MAY RESULT IN CORROSION AND POSSIBLE FAILURE OF THE PART. LANDING GEAR ARE MOST SUSCEPTIBLE. The maintenance of an organic coating (paint) which meets aerospace specification MIL-C-38412 may prevent corrosion.

BOOM EQUIPMENT

For control of herbaceous weeds and woody brush and trees listed in the "Vegetation Controlled" section of this label using conventional boom equipment—Apply this product in 100 to 300 L of clean water per hectare as a broadcast spray using no more pressure than 275 kPa. See "Vegetation Controlled" section of this label for specific rates.

BOOMLESS EQUIPMENT

For control of herbaceous weeds, woody brush and trees listed in the "Vegetation Controlled" section of this label using boomless equipment such as cluster nozzles—Apply this product in at least 300 L of clean water per hectare as a broadcast spray using no more pressure than 275 kPa. See "Vegetation Controlled" section of this label for specific rates.

HAND HELD AND HIGH VOLUME EQUIPMENT
(use coarse sprays only)

For control of herbaceous weeds, woody brush and trees listed in the "Vegetation Controlled" section of this label using knapsack sprayers or high volume spraying equipment utilizing handguns or other suitable nozzle arrangements—See the "Vegetation Controlled" section of this label for specific rates.

Applications should be made on a spray-to-wet basis. Spray coverage should be uniform and complete. Do not spray to point of runoff.

MIST BLOWER EQUIPMENT

For control of herbaceous weeds, woody brush and trees listed in the "Vegetation Controlled" section of this label—Use the recommended rate of this product in at least 200 L of water per hectare. See "Vegetation Controlled" section of this label for specific rates.

VEGETATION CONTROLLED

To control or suppress most herbaceous weeds, woody brush and trees: apply 3 to 6 litres of this product per hectare using aerial, ground boom, boomless or mist blower equipment or apply as a 1 to 2% solution using hand held high volume equipment. Apply as directed in the recommended volume of clean water to foliage of actively growing vegetation. Use the 6 L/ha rate for Maple, Alder and Rubus species, as well as for hard to control perennial weed species.

A PARTIAL LIST OF WOODY BRUSH AND TREE SPECIES CONTROLLED INCLUDES:

Birch Betula spp.	**Raspberry/Salmonberry** Rubus spp.
Cherry Prunus spp.	**Snowberry (Western)** Symphoricarpos occidentalis
Maple Acer spp.	**Willow** Salix spp.
Poplar Populus spp.	**Alder** Alnus spp.

See "Mixing", "Application Instructions" and "Silvicultural Sites" sections of this label for additional information.

For perennial broadleaf weeds: apply when most weeds have reached early head or early bud stage of growth. For annual and perennial grasses: apply when most weeds are at least 20 cm in height (the 3-4 leaf stage of growth).

If herbaceous weeds have been mowed, tilled, or scarified, do not treat until regrowth has reached the recommended stages, as reduced effectiveness will result. Most herbaceous weeds can be treated after a mild frost, provided the leaves are still green and actively growing at the time of application. Do not apply after the first damaging frost. Allow 7 or more days after application before tillage or other soil disturbance. Repeat treatments may be necessary to control weeds regenerating from underground parts or seed.

DIRECTIONS FOR USE

Spray coverage should be uniform and complete. Do not spray to the point of runoff.

Do not allow spray drift to contact non-target desirable vegetation as severe damage may occur.

RESTRICTED USES

SILVICULTURAL SITES

NOTICE TO USER: This control product is to be used only in accordance with the directions on this label. It is an offense under the Pest Control Products Act to use a control product under unsafe conditions.

NATURE OF RESTRICTION: This product is to be used only in the manner authorized; contact local pesticide authorities regarding appropriate use permits that may be required.

Do not apply to any body of water populated with fish or used for domestic purposes. Do not use in areas where adverse impact on domestic water or aquatic species is likely.

In order to reduce the drift hazard to non-target plants and aquatic species when aerially treating silvicultural sites, ensure that appropriate buffer zones are maintained.

SITE PREPARATION, FOREST ROADSIDE AND RIGHTS-OF-WAY VEGETATION MANAGEMENT

Use this product as broadcast treatment at recommended rates to control herbaceous weeds, woody brush and tree species listed in the "Vegetation Controlled" section. Apply when brush and tree species are actively growing and when foliage is full and well-developed. For best results apply in late summer or early fall. Some autumn colors on undesirable deciduous species are acceptable provided no major leaf fall has occurred.

Following site preparation application of this product, any silvicultural species may be planted.

CONIFER RELEASE

Use this product as a broadcast spray at recommended rates to control herbaceous weeds, woody brush and tree species, as listed in "Vegetation Controlled" section of this label, to release from competition the coniferous species listed below:

Douglas Fir Pseudotsuga spp.	**Pine** Pinus spp.
Fir Abies spp.	**Spruce** Picea spp.
Hemlock Tsuga spp.	

Most annual and perennial weeds will be controlled or suppressed. Applications must be made after formation of final conifer resting buds, and 3 to 4 weeks prior to deciduous species leaf senescence. Applications made during period of active conifer growth may result in conifer injury. Avoid application during Lammas or late season conifer growth. Some autumn colors are acceptable provided no major leaf fall has occurred on undesirable brush and tree species.

For conifer release, apply where conifers have been established for more than a year. Vegetation should not be disturbed immediately prior to treatment or until visual signs appear after treatment. Symptoms of treatment are slow to appear, especially on woody species treated in late fall. Injury may occur to conifers treated for release, especially where spray patterns overlap or the higher rates are applied or when applications are made during periods of active conifer growth.

NOTE: This product is not recommended for use as an over-the-top broadcast spray on forest tree nurseries or in year of anticipated harvest in Christmas tree plantations.

INJECTION AND FRILL APPLICATIONS

Woody vegetation may be controlled by injection or frill application of this product. Apply this product using suitable equipment which must penetrate into living tissue. Use this product without dilution and apply at least 1 mL for each 10 cm of trunk diameter breast height (DBH). Space applications evenly around the circumference of the trunk. Application should be made during periods of active growth and full leaf expansion. Control of tree species with tree diameters greater than 20 cm may not be acceptable. A partial list of tree species controlled includes: DOUGLAS FIR (Pseudotsuga spp.), HEMLOCK (Tsuga spp.), CEDAR (Cedrela spp.), MAPLE (Acer spp.), ALDER (Alnus spp.), CHERRY (Prunus spp.), WILLOW (Salix spp.) and BIRCH (Betula spp.). Total control may not be evident until one year after treatment.

FOREST TREE PLANTING NURSERIES

This product may be used to control most annual and perennial weeds for site preparation prior to establishing plantations, or as a post directed spray in established plantations. Application may be made to established deciduous plantings of ASH, Fraxinus spp., CARAGANA, Caragan spp., CHERRY, Prunus spp., ELM, Ulmus spp., LILAC, Syringa spp., MAPLE, Acers spp., MOUNTAIN ASH, Sorbus spp., POPLAR, Populus spp., RUSSIAN OLIVE, Elaeagnus spp., and WILLOW, Salix spp. Applications may be made prior to or in established conifer plantings of FIR, Abies spp., JUNIPER, Juniperus spp., PINE, Pinus spp., SPRUCE, Picea spp., and YEW, Taxus spp. SPRAY MAY CONTACT MATURE BARK ONLY. AVOID SPRAY CONTACT WITH FOLIAGE OR GREEN BARK OF ESTABLISHED PLANTINGS IN POST DIRECTED APPLICATIONS.

For specific rates and applications instructions, see "Mixing", "Application Instructions" and the "Vegetation Controlled" sections of this booklet. DO NOT APPLY UNDER WIND OR OTHER CONDITIONS WHICH ALLOW DRIFT TO OCCUR. If weeds have been mowed or tilled do not treat until regrowth has reached the recommended stages.

This product does not provide pre-emergence weed control. Repeat treatments may be necessary to control weeds generating from underground parts or seed.

NOTE: This product is not recommended for use as an over-the-top broadcast spray in forest tree nurseries or in year of anticipated harvest, in Christmas tree plantations.

PHYSICAL OR CHEMICAL HAZARDS

Spray solutions of this product should be mixed, stored and applied only in stainless steel, aluminum, fiberglass, plastic and plastic-lined steel containers.

DO NOT USE, STORE OR APPLY THIS PRODUCT OR SPRAY SOLUTIONS OF THIS PRODUCT IN GALVANIZED STEEL OR UNLINED STEEL (EXCEPT STAINLESS STEEL) CONTAINERS OR SPRAY TANKS. This product or spray solutions of this product react with such containers and tanks to produce hydrogen gas which may form a highly combustible gas mixture. This gas mixture could flash or explode, causing serious personal injury, if ignited by open flame, spark, welder's torch, lighted cigarette or other ignition source.

STORAGE

Store product in original container only, away from other pesticides, fertilizer, food or feed.

Avoid contamination of seed, feed and foodstuffs.

DISPOSAL

Rinse the emptied container thoroughly and add the rinsings to the spray mixture in the tank. Follow provincial instructions for any required additional cleaning of the container prior to its disposal.

Do not reuse container; destroy when empty. Make empty container unsuitable for further use.

Dispose of container in accordance with provincial requirements.

Soak up small amounts with absorbent clays.

Sweep or scoop up spilled materials and dispose of in approved landfill.

Wash down surfaces (floors, truckbeds, streets, etc.) with detergent and water solution.

Avoid direct applications to any body of water.

Do not contaminate water by disposal of waste or cleaning of equipment.

NOTICE

Seller's guarantee shall be limited to the terms set out on the label and subject thereto, the buyer assumes the risk to persons or property arising from the use or handling of this product and accepts the product on that condition.

NOTICE TO USER: This control product is to be used only in accordance with the directions on this label. It is an offense under the Pest Control Products Act to use a control product under unsafe conditions.

PRINTED IN CANADA

EZJECT™

Capsule Injection System

FOR USE WITH THE EZJECT INJECTION SYSTEM

- Water soluble herbicide paste in a capsule for tree stem injection
- Controls undesirable woody brush and trees .... roots and all
- Contains Four • 48 Tube Cylinders — 4800 Capsules — Each tube contains 25 Capsules
- For use on all forestry, industrial, commercial, right-of-way and other non-cropland sites

---

COMMERCIAL REGISTRATION NUMBER: 21262
PEST CONTROL PRODUCTS ACT

GUARANTEE:
Glyphosate 0.18 grams per capsule present as isopropylamine salt

READ THE LABEL BEFORE USING

CAUTION IRRITANT

PRECAUTION! Keep out of the reach of children
MAY CAUSE EYE IRRITATION
HARMFUL IF SWALLOWED

Avoid contact with eyes or prolonged contact with skin. Wash thoroughly with soap and water after handling.

FIRST AID: IF IN EYES, immediately flush with plenty of water for at least 15 minutes. Call a physician.

IF ON SKIN, immediately wash thoroughly using soap and water. Remove contaminated clothing. Wash clothing before re-use.

IN CASE OF AN EMERGENCY INVOLVING THIS PRODUCT CALL MONSANTO COLLECT, DAY OR NIGHT:

ACCIDENT/SPILLS	(514) 366-5588
MEDICAL EMERGENCY	(314) 694-4000
CANUTEC	(613) 996-6666

MONSANTO CANADA INC.
Streetsville, P.O. Box 787
Mississauga, Ontario L5M 2G4

HALIFAX • MONTREAL • WINNIPEG • SASKATOON • CALGARY • VANCOUVER

Read NOTICE before buying or using. If notice terms are not acceptable, return at once unopened.

ENVIRONMENTAL HAZARDS: Do not contaminate water by disposal of waste.

STORAGE AND DISPOSAL: Ensure that unused capsules are stored tightly sealed in their original container. Capsules should be stored in an upright condition i.e. with open end upwards to avoid any potential of seepage under conditions of high storage temperatures. Store unused capsules below 35°C.

Avoid contamination of seed, feed and foodstuffs. Do not reuse container. Destroy when empty. For information on the disposal of unused, unwanted product and the cleanup of spills contact the regional office of Conservation and Protection, Environment Canada.

DIRECTIONS FOR USE: Capsules: Woody vegetation may be controlled by injection application of this product. Apply this product using suitable equipment which must penetrate into living tissue. Apply at least 1 capsule for each 5 cm of trunk diameter breast height (DBH). Space applications evenly around the circumference of the trunk. Application should be made during periods of active growth and full leaf expansion. Treatment should not be made to trees or brush after fall leaf drop has begun.

Control of trees species with tree diameters greater than 20 cm may not be acceptable. A partial list of tree species controlled includes DOUGLAS FIR (Pseudotsuga spp); HEMLOCK (Tsuga spp); CEDAR (Cedrela spp); MAPLE (Acer spp); ALDER (Alnus spp); CHERRY (Prunus spp); WILLOW (Salix spp) and BIRCH (Betula spp). Total control may not be evident until one year after treatment.

NOTICE: Sellers guarantee shall be limited to the terms set out on the label and subject thereto, the buyer assumes the risk to persons or property arising from the use or handling of this product and accepts the product on that condition.

NOTICE TO USER: This control product is to be used only in accordance with the directions on this label. It is an offense under the Pest Control Products Act to use a control product under unsafe conditions.

Canadian Patent: 936,865

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Monsanto Canada is a registered user.

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LOT NO: 0190727

GEL CAP™

KEEP IN A COOL, DRY PLACE

DIRECTIONS

1) Turn "20 pack" over and tear off perforated end of packages
2) Capsules are now exposed upside down (with closed end and screwhead showing)
3) Place closed end of capsule into GEL CAP* application tool so that screwhead contacts screwdriver
4) Screw into tree below lowest branch
5) GEL CAP* is properly seated when: a) — bark has been penetrated
   b) — capsule is snug
   c) — no air gaps exist between capsule and bark
6) One GEL CAP* per 10 cm. of tree diameter – refer to VISION® label for Species Control
7) For more detailed information on the GEL CAP* Application Tool – refer to instructions with tool

CONTENTS: 1000 × 1 ml capsules (50 × 20 pack)

Trademark of PACE CHEMICALS LTD. VISION is a registered trademark of Monsanto Company U.S.A., Monsanto Canada Inc. Registered user

PACE CHEMICALS LTD.

8321 WILLARD ST., BURNABY, B.C. V3N 2X3 (604) 520-6211

APPENDIX IV

Description of Tools

Vredenburg Girdling Tool

The Vredenburg girdling tool (see Figure 3) resembles a large pair of pliers with toothed inner "blade" edges and cupped rakers riveted to the blades. Dimensions of the Vredenburg girdling tool are given in Table IV-1. When this tool is closed around a tree stem and rotated, it scrapes a ring of bark and cambium from the stem, thus preventing essential nutrients from moving through the tree. Previous studies have indicated that this tool works best for girdling stems with diameters between 3 and 16 cm.[1] As well as the Vredenburg girdling tool, there are several other tools available for girdling. Girdling tools range in price from about $100 to $200.

Table IV-1. Dimensions of Vredenburg Girdling Tool

Length	41 cm
Weight	1 085 g
Purchase cost	$100-200

GEL CAP System

The GEL CAP is a cylindrical nylon capsule; it is closed at one end and has a bevelled edge at the open end (Figure IV-1). A screw with a Phillips head runs longitudinally through the centre of the capsule. The cylinder is filled with 1 mL of gelled VISION (glyphosate). The capsules are applied to the target trees using a drill fitted with an applicator bit to drive the screw into the wood of the trees. The bevelled edges of the capsule cut through the bark and the cambium allowing the sap of the tree to soften the gelled VISION which in turn translocates within the tree. Specifications for the GEL CAP capsules, the extension bit, and the cordless drill are provided in Table IV-2.

GEL CAP Extension. The GEL CAP applicator consists of a Phillips screwdriver bit surrounded by a freely rotating externally threaded collar (D). Over this collar fits the spacer (C) and the sleeve (B) which are threaded to match the collar. The sleeve is the part that accepts the GEL CAP (A); it has a rubber O-ring at its open end to provide the tension that holds the capsule in place while it is being applied to the tree.

Makita Cordless Driver Drill. The drill used in this study, and recommended by Pace Chemicals Ltd., is the model 6071D reversible cordless drill (Table IV-2). The rechargeable battery fits into the drill's handle and can be recharged with either of the rechargers.

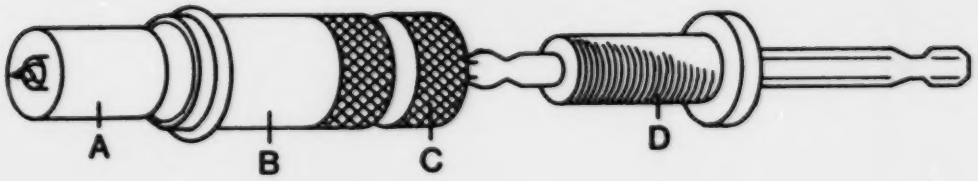

Figure IV-1. GEL CAP capsule and applicator.

[1] Weaver (1983), and I.B. Hedin, 1983, "A comparison of productivity of girdling and hack-and-squirt techniques in conifer release;" FERIC Interim Report IR-383-2, unpublished.

Table IV-2. Specifications for GEL CAP Equipment

GEL CAP	
Dimensions	Diameter - 1.5 cm; Length - 2.0 cm
Weight	6 g (filled with VISION)
Supplied by	Pace Chemicals Ltd.
Makita drill	
Model	6071D reversible cordless with variable speed control
Weight with battery	1 135 g
Bit capacity	1.5 mm to 10 mm
Power source	7.2 V nickel-cadmium battery
Makita fast chargers	DC 7100 115 V - household power supply DC 7012 12 V - automobile cigarette lighter
Purchase cost	$250

Hack-and-Squirt Tools

For the hack-and-squirt treatments, FERIC used hatchets and the Du Pont disposable spotgun. A reservoir, consisting of a plastic bottle containing a 50% solution of VISION herbicide, was carried on the operator's belt (Table IV-3). A plastic suction tube joined the reservoir to the spotgun; when the spotgun's trigger is depressed, the plunger is activated and a measured dose of chemical is squirted at the target. An adjustment nut on the top of the gun alters the length of the trigger stroke, thus setting the quantity of herbicide that will be discharged. The longer the stroke, the more chemical discharged through the nozzle. Numerous other systems are available, such as squirt bottles and oil cans, that would allow measured doses and could replace the spotgun/reservoir system. The purchase cost of these tools varies from $30 to $80 depending on the delivery system selected.

Table IV-3. Weights and Dimensions of Hack-and-Squirt Tools

Hatchet	
Length	38 cm
Weight	875 g
Spotgun	
Weight	100 g
Reservoir	
Weight	1 000 g
Purchase cost	$30-80

EZJECT

The EZJECT system was initially designed by Brian Dillistone and was known as the Wee-Do. In the last few years, Monsanto has been developing a commercial model under the name EZJECT. The EZJECT lance unit (Table IV-4) consists of two main parts: the shaft, containing a four-chambered magazine, and the head, containing the mechanisms that enable the lance to inject 0.22-calibre shells into the target trees (Figure IV-2). The EZJECT shells are loaded in the chambers of the magazine and fed by gravity to the head when the lance is in use. The sloped head of the lance has five sharp prongs to grip the surface of the tree. An injection is accomplished by firmly thrusting the lance against the target tree. This action causes the head, which is spring loaded, to retract allowing a plunger to push the 0.22-shell into the target tree's bark. When the head re-extends, a new shell drops in the chamber for the next injection.

Table IV-4. Description of EZJECT

Length	1.53 m
Weight	4.6 kg
Estimated purchase cost	$500

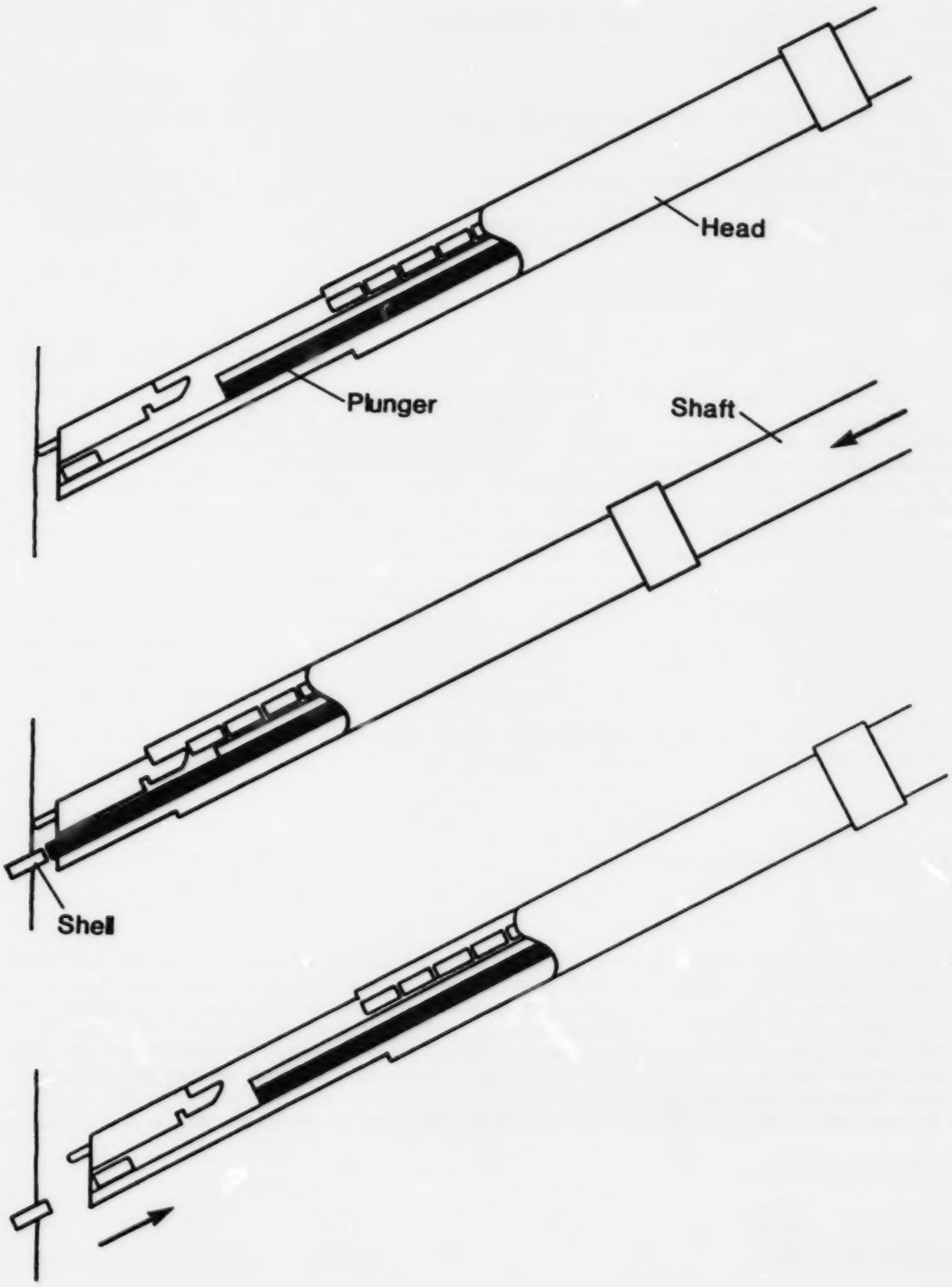

Figure IV-2. Operation of EJJECT lance head.